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A Pollutant transport investigated through an expansive clay

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In the framework of domestic waste disposals, the in-situ compaction of soil is usually used to obtain engineered clay barriers with suitable confining properties. Permeability and pollutant retention are the major properties which should be investigated in this context for barrier evaluation. Considering clay barriers in contact with waste leachates, they may be saturated by solutes of various chemical compositions, including in particular toxic heavy metals. In this context, the expansive Fo-Ca clay, a natural Ca-smectite from the Paris basin of Ypersian (Sparnacian) age, was chosen because of its very low permeability and ability for pollutant retention through cationic exchanges. The smectic is associated with kaolinite (up to 20%), and minor quartz, calcite, goethite and gypsum.

An experimental work (JULLIEN *et al.,* 2002) was performed to analyse the Fo-Ca performances when submitted to chemo-hydro-mechanical coupled effects produced by soaking the clay with a polluted solute. For this purpose, tests were performed using 10^{-1} mol/l $Cu(NO_3)_2$ solution. The evolution of leachate chemical composition was carried out as a function of time in order to characterise the ability of the clay to copper retention (fig 1).

The previous studied clay samples can be considered as a system submitted to an external parameter (x(t)) and delivering a response to it (y(t)). The copper behaviour can be modelling with a like global equation 1.

$$\left.\begin{array}{c} x(t) = Bt \\ \text{Intake copper flux} \end{array}\right\} \longrightarrow \boxed{\begin{array}{c} TL^{-1}H(s) \\ \text{Or Clay} \end{array}} \longrightarrow \left\{\begin{array}{l} y(t) = B\,(t-\tau + \tau\, e^{(-t/\tau)}) \\ \text{Copper flux in leachate} \end{array}\right. \qquad (1)$$

where B is $\partial M/\partial t$ (with M is the molar concentration of the input copper solution (mol/L)), TL^{-1} is the Laplace transform, τ is the time constant (hour), and H the gain in the permanent regime.

Simulated curves using different copper concentrations are presented on figure 2. To validate this model, an experiment was carried out with a 0.5 mol/l $Cu(NO_3)_2$ solution. The model allows to predict the behaviour of more dilute copper solution representative of waste leachate through a clay barrier.

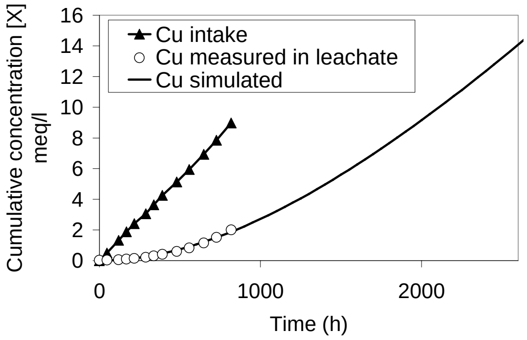

figure 1 : experimental concentrations of copper

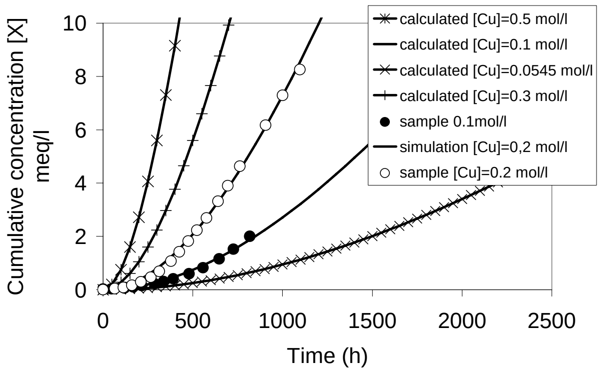

figure 2 : simulated curves of different copper concentrations

References

A. Jullien, C. Proust, L. Le Forestier, P. Baillif. "Hydro-Chemio-mechanical coupling effects on the properties of a Ca smectite." Applied Clay Science, 21, 143– 153 (2002)